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ORTHODONTICALLY INDUCED ROOT RESORPTION IN MAXILLARY FIRST MOLAR DURING CANINE RETRACTION ON MINI-IMPLANT

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ABSTRACT:

Objective: *The aim of this study was to compare between the incidence of orthodontically induced root resorption (OIRR) of maxillary first molar during canine retraction utilizing conventional sliding mechanics and mini-implants assisted mechanics.* ***Methods:*** *The sample in this study consisted of 20 subjects, which were randomly and equally divided into two groups: group A; Conventional sliding mechanics group consisted of 10 subjects (7 males and 3 females) and group B; Mini-implant assisted mechanics group consisted of 10 subjects (5 males and 5 females). CBCT were taken before treatment and after canine retraction to evaluate the degree of OIRR. Paired t-test and ANOVA were used to compare the extent of OIRR in both groups and between the mesiobuccal, distobuccal, and palatal roots within each group pretreatment and post-retraction.* ***Results:*** *Displayed a statistically significant increase in OIRR of maxillary first molar with conventional sliding mechanics (P-value <0.001) and mesiobuccal root exhibited the highest degree of OIRR and the palatal root had the lowest OIRR within both groups.* ***Conclusion:*** *Mini-implant assisted mechanics during canine retraction decreases the amount of OIRR in the maxillary first molars than implementing conventional sliding mechanics.*

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INTRODUCTION

Treatment of skeletal Class II in nongrowing individuals might involve surgical intervention, orthodontic camouflage, or maxillary molar distalization. Orthognathic surgery is generally declined despite its good results due to its costs and related risks [1]. Orthodontic camouflage on the other hand involves either extraction of four first premolars or only two maxillary first premolars (indicated when there is no cephalometric discrepancy or crowding in the mandibular arch) [2] then retraction of the canines and incisors. However, anchorage control (especially in maximum situations) could be critical causing canine retraction to be an strenuous task [3]. Intraoral anchorage techniques are not always fruitful, yet extraoral anchorage such as headgears have shown to be effective but the problems associated with patient compliance, unfavorable effects on the maxillary complex, and the hazard of injuries have jeopardized their success [3].

In order to overcome the problems associate with traditional anchorage mechanics temporary anchorage devices (TADs) were introduced. TADs have altered the conventional orthodontic concepts of biomechanics in anchorage control and simplified treatment. Introduction of skeletal anchorage has allowed absolute anchorage and complete closer of extraction spaces via anterior tooth retraction[4]. Among the various TADs are Mini-implants; they allow reliable three-dimensional anchorage and liable treatment outcomes. Mini-implants have several advantages; easy placement, few limitations in implantation sites, stable, immediate loading, and impose the least trauma on oral tissues. Furthermore, mini-implants are relatively inexpensive and independent on patient cooperation [5-9]. Experimental and clinical studies, state that orthodontic mini-implants (OMIs) can provide sufficient and stable anchorage for orthodontic treatment [10,11].

OIRR is frequently cited as a deleterious effect of orthodontic treatment[12,13]. OIRR is caused by the biologic changes in the cementum and the periodontal ligament associated with the concentration of orthodontic forces on the apical root third [12]. The incidence of OIRR is common in posterior teeth, with 47% undergoing root blunting, 27% developing moderate root resorption and 6.5% with severe resorption with loss of one third of pretreatment root length[13]. The clinical gold standard for measuring tooth length and estimating root resorption is the parallel periapical radiographic technique[14-18]. Conversely, periapical radiographs are prone to orientation, procedural, and projection errors. Therefore periapical radiographic orientation errors and overlapping problems could be overcome with cone-beam computed tomography (CBCT), a radiographic substitute.

However, the diagnostic ability of CBCT in detecting OIRR has not been sufficiently studied especially during canine retraction. Although canine retraction is perhaps the utmost common clinical situation where sliding mechanics is implemented to move a tooth over a relatively sizable space. Therefore, the aim of this study was to compare the incidence of OIRR in maxillary first molar (U6) during canine retraction utilizing conventional sliding mechanics and mini-implants assisted mechanics.

MATERIALS & METHODS

The sample in this study consisted of 20 subjects selected from the outpatient clinic of the orthodontic department, Faculty of Dentistry, Ain Shams University. The subjects were randomly and equally divided into two groups: group A; Conventional sliding mechanics group consisted of 10 subjects (7 males and 3 females) and group B; Mini-implant group consisted of 10 subjects (5 males and 5 females).

The inclusion criteria were: Non-growers with age range between 18 to 25 years (mean age 21.5). All subjects had complete permanent dentition, except third molars and presented Angle Class II div. 1 malocclusion with excessive overjet (>5mm). This entailed bilateral therapeutic extraction of the maxillary first premolars and retraction of the maxillary canines with maximum anchorage. All subjects had complete permanent dentition, except third molars. The exclusion criteria were; dental anomalies, systemic diseases, periodontal diseases, previous orthodontic treatment, history of dental trauma, endodontic treatment and radiographic signs of external apical root resorption (EARR).

All subjects or their guardians signed an informed consent after receiving detailed information about the planned orthodontic treatment.

The ethical committee of the Faculty of Dentistry Ain Shams University approved this study protocol. Subjects that satisfied the previous criteria were required to complete a full set of orthodontic diagnostic records. All records were taken for each subject at two intervals; pretreatment at T1 and at T2 after complete maxillary canine retraction (post-retraction). These records included; a diagnostic sheet, an orthodontic study cast, Extra & Intra oral photographs and CBCT.

The orthodontic treatment was performed with a full fixed standard edgewise appliance for both groups, which included bands on molars and edgewise brackets with Roth prescription, 0.022 x 0.030 inch slot (3M Unitek, Monrovia, Calif). In-group A a transpalatal arch was placed for anchorage reinforcement. Whereas; in-group B Mini-implant (Abso Anchor, Dentos, Daegu, Korea; diameter, 1.3 mm; length 8 mm) were placed between the maxillary second premolars and the maxillary first molars.

After alignment and leveling in both groups canine retraction on 0.016 x 0.022 inch stainless steel (St.St.) archwires was commenced as follow; ingroup A the first molars and second premolars were tied together with St.St. 0.010-inch ligatures to establish the anchor unit upon which canine retraction was implemented (figure 1). In-group B canine retraction was accomplished via direct loading on the mini-implant (figure 2). The orthodontic load for retraction of the canines in both groups was accomplished via nickel-titanium closed-coil spring (Sentalloy, Tomy, Tokyo, Japan), with a force magnitude of 150 gm.

CBCT images were taken utilizing the Scanora 3D radiograph CBCT machine (Soredex, Tuusula, Finland). The specification of the CBCT machine were; 85KV, 15mA, 6 second exposure time, 2.6 second scanning time, amorphous silicon flat panel, 0.35 mm voxel size, 0.5 mm focal spot, and 13cm×15cm (FOV). The DICOM files were then imported into a 3D computer software; (Sim Plant Pro 11.04, Materialize, Belgium).

The CBCT scans were assessed by the same researcher in order to measure root length at (T1) pretreatment and (T2) post-retraction utilizing the specific computer software program in the following manner: The coronal, sagittal, and axial planes were adjusted to intersect in the root canal of the root in question for the maxillary first molar (Mesiobuccal, Distobuccal, and Palatal) as shown in (figure 3). The root length was measured in millimeters from the most apical point of the root to the cusp tip of the maxillary first molar for each of the 3 roots (Mesiobuccal, Distobuccal, and the Palatal), along the long axis in the sagittal view as shown in (figure 4).

Statistical analysis:

All the measurements were presented into an excel spreadsheet and analyzed using a statistical software package (SPSS version 15.0, Chicago, Ill) for Windows. Paired t-test was used to compare between the extent of OIRR for each root within each group (A&B) pretreatment and post-retraction. Analysis of variance (ANOVA) and Kruskal Wallis (Nonparametric Chi-squared) tests were used to compare incidence OIRR between the three roots (mesiobuccal, distobuccal, & palatal) within each group (A&B) pretreatment and post-retraction. Bonferroni test was used for multiple comparisons of the OIRR amid each pair of roots within each group pretreatment and post-retrac btion. P value of ≤0.001 was used to assign statistical significance. Intraclass correlation coefficient (ICC) was calculated to calibrate for intraexaminer error by two independent sets of measurements made by the same operator 3 or 4 days apart.

Figure 1. Canine retraction conventionally.

Figure 2. Canine retraction assisted via mini-implants.

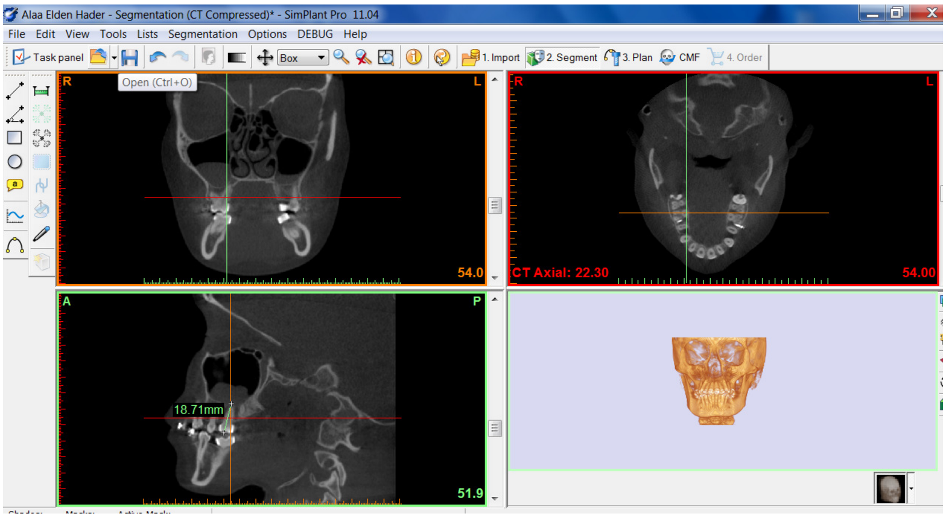

Figure 3. The coronal, sagittal, and axial planes were adjusted to intersect in the root canal of the palatal root for the maxillary first molar.

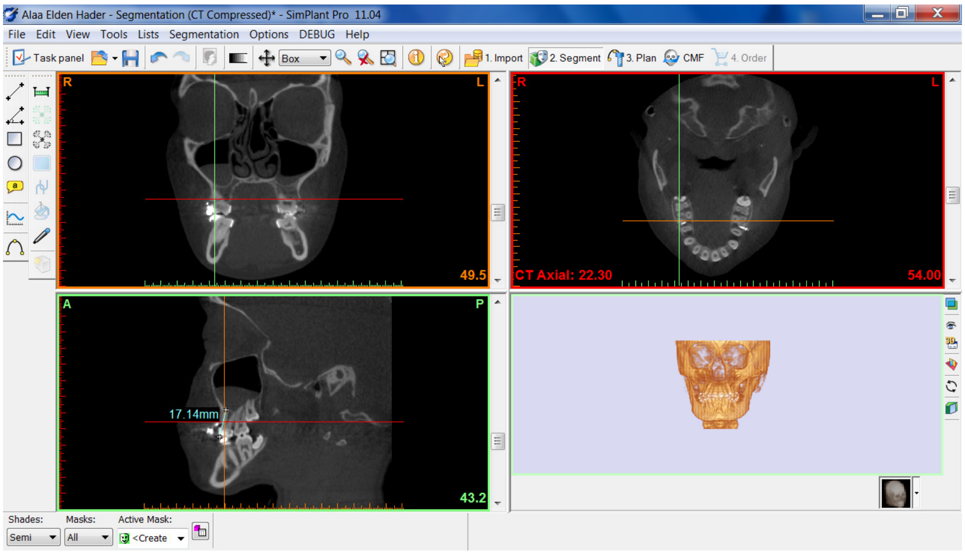

Figure 4. The root length measured in millimeters from the most apical point of the mesiobuccal root to the mesiobuccal cusp tip of the maxillary first molar along the long axis in the sagittal view.

RESULTS

Table 1. Shows the amount of OIRR (mean difference) for all three roots the mesiobuccal, distobuccal, and palatal of the U6 in both groups. The mean amount of OIRR in the mesiobuccal root of the maxillary molar in the conventional sliding mechanics and the mini-implant assisted mechanics were 2.04mm and 0.47mm respectively. Whereas the mean amount of OIRR in the distobuccal root of the maxillary molar in the conventional sliding mechanics and the mini-implant assisted mechanics were 1.06mm and 0.24mm respectively. While the mean amount of OIRR in the palatal root of the maxillary molar in the conventional sliding mechanics and the mini-implant assisted mechanics were 0.47mm and 0.10mm respectively.

Table 2. Expresses the paired t-test for comparison of the degree of OIRR within the three roots of the U6 with the implementation of conventional sliding & mini-implant assisted mechanics. The results indicate that there is a statistically highly significant difference between the root lengths pretreatment and post-retraction for each root the mesiobuccal, distobuccal, and palatal where the P-value <0.001.

Table 3. Demonstrates ANOVA test for comparison of the difference between the lengths for the three roots of the maxillary first molar pretreatment and posttreatment within each group (conventional sliding & mini-implant assisted mechanics). The results imply that the amount of EARR within the mesiobuccal, distobuccal, and palatal roots are statistically highly significant for both groups with a P-value <0.001. These results are further confirmed by the results from the Kruskal Wallis non-parametric test shown in table 3.

Table 4. Shows Bonferroni method for multiple comparisons between each pair of roots for the U6 pretreatment and post-retraction within each group. The results denote that the amount of OIRR between the mesiobuccal and distobuccal roots, mesiobuccal and palatal roots, and distobuccal and palatal roots are statistically highly significant for both groups with a P-value <0.001.

Table 5. Displays independent sample t-test for comparison of the degree of OIRR in U6 for each root between the two groups (conventional sliding mechanics & mini-implant assisted mechanics).

The results denote that the amount of OIRR within all three roots the mesiobuccal roots, distobuccal roots, and palatal roots between the conventional sliding mechanics & mini-implant assisted mechanics group are statistically highly significant with a P-value <0.001.

Figure 5. Illustrates a graphic presentation comparing the amount of OIRR within each root (mesiobuccal, distobuccal, & palatal) between the two methods (conventional & mini-implant mechanics). The figure indicates that the amount of OIRR within the mesiobuccal roots of the U6 for the conventional sliding mechanics & mini-implant assisted mechanics groups are 2.04 and 0.47mm respectively, with an increase in the amount of OIRR in the conventional sliding group by a value of 1.57mm. The figure shows that the amount of OIRR within the distobuccal roots of the U6 for the conventional sliding mechanics & mini-implant assisted mechanics groups are 1.06 and 0.24 mm respectively, with an increase in the amount of OIRR in the conventional sliding group by a value of 0.82mm. The figure correspondingly indicates that the amount of OIRR within the palatal roots of the U6 for the conventional sliding mechanics & mini-implant assisted mechanics groups are 0.47 and 0.10mm respectively, with an increase in the amount of OIRR in the conventional sliding group by a value of 0.37mm.

Table 1. Shows the amount of OIRR (mean difference) for all three roots of the U6 in both groups (A&B).

	Group A Conventional mechanics			**Group B Mini-implants assisted mechanics**		
	Mean	**SD**	**P-value**	**Mean**	**SD**	**P-value**
Mesiobuccal root pre	17.83	0.56		18.12	0.71	
Mesiobuccal root post	15.79	0.53	0.00000	17.66	0.72	0.00000
Mesiobuccal root (Post-Pre)	2.04	0.11		0.47	0.04	
Distobuccal root pre	18.14	0.60		18.41	0.75	
Distobuccal root post	17.08	0.60	0.00000	18.17	0.75	0.00000
Distobuccal root (Post-Pre)	1.06	0.10		0.24	0.03	
Palatal root pre	20.59	0.67		20.76	0.79	
Palatal root post	20.13	0.68	0.00000	20.67	0.79	0.00000
Palatal root (Post-Pre)	0.47	0.10		0.10	0.03	

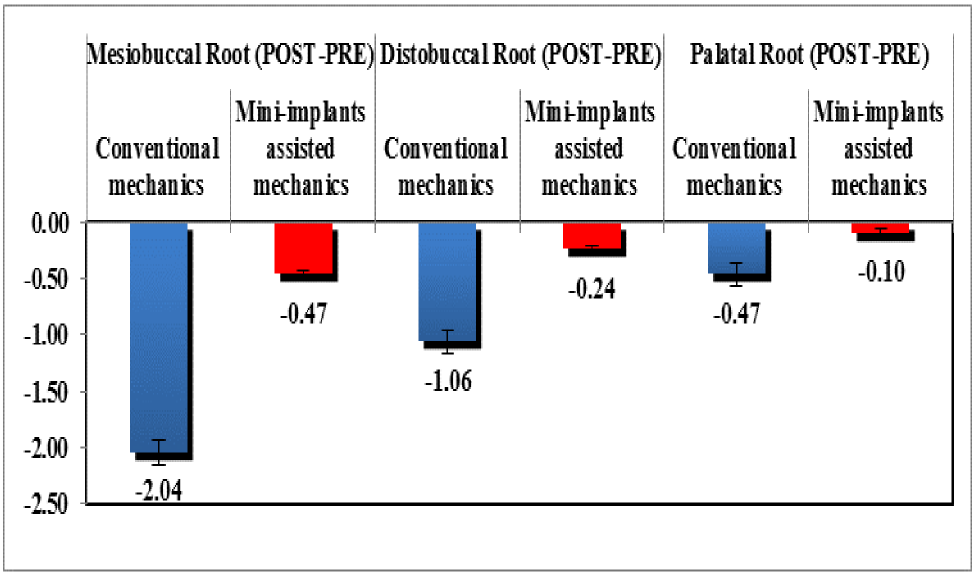

Figure 5. Shows a graphic presentation comparing the amount of OIRR within each root (mesiobuccal, distobuccal, & palatal) between the two methods (conventional & mini-implant mechanics).

Table 2. Shows ANOVA test for comparison of the difference between the three roots of the U6 pretreatment and post-retraction within each group.

		ROOT	Mean	Std. Deviation	F	P-Value
Group 1	Conventional mechanics effect on root resorption of maxillary first molars	Mesiobuccal Root (POST-PRE)	-2.04	0.11	605.2	0.00000
		Distobuccal Root (POST-PRE)	-1.06	0.10		
		Palatal Root (POST-PRE)	-0.47	0.10		
Group 2	Mini-implants assisted mechanics effect on root resorption of maxillary first molars	Mesiobuccal Root (POST-PRE)	-0.47	0.04	284.4	0.00000
		Distobuccal Root (POST-PRE)	-0.24	0.03		
		Palatal Root (POST-PRE)	-0.10	0.03		

Table 3. Shows Kruskal Wallis non-parametric test for comparison of the difference between the three roots of the U6 pretreatment and post-retraction within each group.

		ROOT	Mean Rank	Chi-squared	DF	P-value
Group 1	Conventional mechanics effect on root resorption of maxillary first molars	Mesiobuccal Root (POST-PRE)	5.50	25.92	2	0.00000
		Distobuccal Root (POST-PRE)	15.50			
		Palatal Root (POST-PRE)	25.50			
Group 2	Mini-implants assisted mechanics effect on root resorption of maxillary first molars	Mesiobuccal Root (POST-PRE)	5.50	26.37	2	0.00000
		Distobuccal Root (POST-PRE)	15.50			
		Palatal Root (POST-PRE)	25.50			

Table 4. Shows Bonferroni methods for multiple comparisons between each pair of roots for the U6 pretreatment and post-retraction within each group.

				Mean Difference	Std. Error	P-value
Group 1	Conventional mechanics effect on root resorption of maxillary first molars	Mesiobuccal Root (POST-PRE)	Distobuccal Root (POST-PRE)	-.981	.04575	0.00000
		Mesiobuccal Root (POST-PRE)	Palatal Root (POST-PRE)	-1.576	.04575	0.00000
		Distobuccal Root (POST-PRE)	Palatal Root (POST-PRE)	-.595	.04575	0.00000
Group 2	Mini-implants assisted mechanics effect on root resorption of maxillary first molars	Mesiobuccal Root (POST-PRE)	Distobuccal Root (POST-PRE)	-.223	.01554	0.00000
		Mesiobuccal Root (POST-PRE)	Palatal Root (POST-PRE)	-.368	.01554	0.00000
		Distobuccal Root (POST-PRE)	Palatal Root (POST-PRE)	-.145	.01554	0.00000

Table 5. Shows independent sample t-test for comparison of the degree of OIRR U6 for each root between the two groups (conventional & mini-implant).

	Groups	Mean	Std. Deviation	Mean Difference	Std. Error Difference	t	P-value
Mesiobuccal Root (POST-PRE)	Conventional mechanics	-2.04	0.11	-1.58	0.04	-43.43	0.00000
	Mini-implants assisted mechanics	-0.47	0.04				
Distobuccal Root (POST-PRE)	Conventional mechanics	-1.06	0.10	-0.82	0.03	-25.62	0.00000
	Mini-implants assisted mechanics	-0.24	0.03				
Palatal Root (POST-PRE)	Conventional mechanics	-0.47	0.10	-0.37	0.03413	-10.78	0.00000
	Mini-implants assisted mechanics	-0.10	0.03				

DISCUSSION

Treatment of skeletal Class II malocclusion in adults frequently requires premolar extractions and maximum anchorage, which might be difficult. One of the biomechanical alternatives to space closure is the retraction of canines first via sliding mechanics before incisor retraction. In order to obtain acceptable results regarding reduction of overjet, anchorage reinforcement measures whether intraoral or extraoral might be required. However, establishment of absolute anchorage for incisor retraction with such measures might lead to minimal improvement. This steered orthodontist to pursuit an appliance that provides an increase in treatment efficiency, biocompatibility, and patient convenience this led to the evolution of titanium mini-implants.

Titanium mini-implants are presently in vogue since they are suitable for various orthodontic tooth movements with few anatomic limitations on placement, ability of immediate loading, ease of implantation and removal and low cost[19,20]. There are numerous citations addressing mini-implants regarding their role in orthodontic anchorage[5-10]. However, there is still no consensus in these studies concerning the incidence of orthodontically induced root resorption (OIRR) and the implementation of mini-implants as anchorage reinforcement. OIRR is a common iatrogenic problem associated with orthodontic treatment as a consequence of mechanically induced tooth movement[21], yet its causes are still inadequately understood. The literature insinuates that extensive movement of teeth with mature roots; increase the risk of OIRR that transpires during treatment when forces at the apex surpass the resistance and reparative capability of the periapical tissues [22-27]. However it is hard to separate and assess specific tooth movements that are liable to enhance OIRR due to the blends of complex mechanical tooth movements, such as extrusion, intrusion, translation, tipping, torqueing, and rotations, that are created by a wide array of orthodontic appliances. Thus the aim of this study was to compare whether utilization of mini-implants as anchorage for canine retraction reduces the incidence of OIRR on the maxillary first molar.

This study was performed on Angle Class II div. 1 malocclusion adults with excessive overjet of more than 5.0 mm due to their increased frequency in seeking orthodontic treatment. Root length measurements derived from periapical radiographs were less accurate than those from CBCT scans leading to underestimation in 95% of the time [28] thus in this study root length measurements were evaluated on CBCT scans.

The results in this study indicate that the incidence of OIRR in all three roots of the U6 (mesiobuccal, distobuccal, and palatal) in group A (Conventional sliding mechanics) was higher than in group B (Mini-implant assisted mechanics). This could be attributed to both the heavy force magnitude and duration to which the U6 was subjected during the utilization of conventional mechanics whereas in the mini-implant assisted method all the force was on the mini-implant via direct traction. It is believed that higher forces trigger more extensive OIRR because the more rapid rate of lacuna development, which compromises the tissue repair process[29-31]. This concurs with the results of Weiland and Faltin et.al who found that discontinuous forces resulted in lower OIRR than the application of a continuous force[32,33] since the pause in the force permits the resorbed cementum to heal and prevents further resorption. This finding controverts results from an earlier, split-mouth experiment by Owman-Moll et al[34] in which there was no difference in amount of OIRR between teeth that were moved with either a continuous or an interrupted force.

The results in this study implies that the amount of OIRR within the mesiobuccal, distobuccal, and palatal roots of the maxillary first molar for the conventional sliding mechanics to be 2.04,1.06 and 0.47mm respectively, with the highest degree of OIRR in the mesiobuccal root and the lowest amount in the palatal root. Whereas; the degree of OIRR in the mini-implant assisted mechanics group followed a similar pattern but with lower values within the mesiobuccal, distobuccal and palatal roots of the maxillary first molar 0.47,0.24, and 0.10mm respectively, this could be accredited to the type of tooth movement. The maxillary first molar tips mesially during canine retraction, this mesial tipping results in intrusion of the mesiobuccal root tip and extrusion of the distobuccal root tip. This agrees with previous literature indicating that the greatest damage is observed with intrusive tooth movements, since they concentrate pressure at the tooth apex[29,35-37]. The results of this study disclosed that the lowest amount of OIRR in the palatal root of the maxillary first molars for both groups this might be credited to the root morphology and length, in addition to the tooth movement. Convergent apical root canal is considered to be an indicative of high root resorption potential[38].

CONCLUSIONS

- Mini-implant assisted mechanics during canine retraction decreases the amount of OIRR in the maxillary first molars than implementing conventional sliding mechanics.
- OIRR follows a pattern in the maxillary first molars with the highest degree occurring in the mesiobuccal root and the lowest degree in the palatal root for both mechanics.

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